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Cloudlet architecture for dashboard in cloud and ubiquitous manufacturing

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* Corresponding author. Tel.: +351-961842189; E-mail address: lufer@ipca.pt.**Abstract**

The aim of this paper is to present a cloudlet architecture for dashboard in Cloud and Ubiquitous Manufacturing. In practice means that, with Cloud Computing adoption, Manufacturing requires management applications where ubiquity and effectiveness are enabled. If ubiquity and resources scalability, availability and capacity can be well supported by cloud, pragmatics instruments are required to support effectiveness. The architecture here presented shows the integration of enriched existing (cloud) services, as instances of resources, with layers of new services towards direct and synchronous communication between users. These Rich Internet Application (RIA) components, here named *cloudlets*, integration, follow dashboards organization patterns and will be supported by emergent web3.0 interaction technologies. In fact, the paper proposes a new Presentation Layer to be used in UMS and (that may be used) in any multi-layer cloud-based web application.

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*Keywords: Cloud Manufacturing; Ubiquitous Manufacturing; Pragmatics; User Pragmatics; Interoperability; User Experience; Cloudlet***1. Introduction**

Socially, “*Manufacturing is a key element of Europe’s competitiveness. It is widely accepted that ICT is the major contributor to manufacturing innovation, productivity and jobs*” (CORDIS, 2005) and “*to boost European competitiveness ...Europe’s manufacturing sector must fundamentally change its attitude and approach to business. Better use of information and communication technology (ICT) offers the key to meeting the challenges by enhancing end-to-end manufacturing processes from shop floor to customer*

engagement and all along the supply chain” (Majumdar & Szigeti, 2011).

Technologically, Cloud and Ubiquitous are emergent buzzwords for Computing and Information Systems, respectively. The increasing interest and tentative to adopt them, make them relevant factors in nowadays continuous business models changes.

Literature announces (virtually) unlimited capacity with Cloud Computing (CC) (Charlton, 2008), and Ubiquitous Information System (UIS) grants permanent services availability. We defend that both properties (together) represent the perfect setting for future

Manufacturing support and sustainability (Cloud and Ubiquitous Manufacturing Systems – CUMS).

Even existing standards and patterns on enterprise and applications integration, the effective integration is still complex and not sufficiently agile (W@tch, 2006).

Nomenclature

UMS	Ubiquitous Manufacturing System
CC	Cloud Computing
ICT	Information Communication Technology
CUMS	Cloud Ubiquitous Management System

This paper proposes a cloudlet architecture for a dashboard to monitoring Cloud Ubiquitous Manufacturing System, where integrated effectiveness with communicational instruments is assured.

2. Cloud and Ubiquitous Manufacturing challenges

As happened with multiple economic activities, traditional manufacturing has been hardly “shaken” to efficiently integrate ICT in their processes. Nevertheless, efforts to modernizing legacy applications (or initial investments) and to capitalize traditional knowledge, still continue to slow down an efficient ICT adoption and consequent business model changes, essential requirement to re-align with new market requirements. In all this process the human has been a passive actor and the knowledge does not represent the real human capital. Indeed, following working processes (flow) and responding to system’s events does not allow the co-creation of knowledge.

2.1. More than an innovative business model

ICT has brought new economic and commercial relations and provided a global (virtual) market, with new entities and new rules. Agility and quickness are critical in nowadays competitiveness requirements. *“Globalization, innovation and ICT are transforming many sectors to anywhere, anytime platforms”*, towards an intelligent business model under *“design anywhere, make anywhere, sell anywhere”* paradigm (Elliott, 2010). We would add “anytime” too. Traditional suppliers and customers are “transformed” in services, where supplying or using profiles are a question of needs or context. One service (a *Calculator*, for instance) can execute (supply) something using other services (*Add, Sub, Mult and Div* operations) (Usmani, Azeem, & Samreen, 2011).

Manufacturing has been looking for low cost processes and scalable resources capacity. These

resources, even in a global market, must be discovered, selected and managed, and the capacity and efficiency to get the “best” ones will be determinant. Some intelligence must be put in this process (Mostafaeipour & Roy, 2011), but it is not enough to achieve the expected efficiency and sustainability. Ubiquitous Manufacturing sustains the needed agility and quickness to react to market changes (Putnik, 2010; Putnik & Putnik, 2010).

Although being autonomous resources (services), i.e., projected and created “to work alone”, these resources could not be sufficiently integrated or integratable (Mackie, 2007; Singh, 2003).

However, not only these technological trends influence the course of the things, social-economic trends as consumption growing, globalization, innovation and sustainability policies, determine new orientations too (Majumdar & Szigeti, 2011). So the challenge is not only the ICT adoption but more the way one does it. *“...the biggest problem is not the availability or implementation of technology: it’s changing the mindset of the people themselves”* (Elliott, 2010).

2.2. ICT, Dashboards and Cloud Manufacturing

Cloud computing is much more than unlimited IT capacity (processing, hosting, etc.). It is an opportunity to achieve, indeed, new business models.

The Web will continue to be the main channel to support business activities. Furthermore, the success of human capital promotion with social media, and the new communicational (smart) devices capacities, brings web (wired or not) to high levels of intelligence support, leaving far behind the initial syntactic hypertext model and its semantic content models successor. Web (3.0 and 4.0) (Figure 1) will support value creation and (self) efficient business models to use it (Bhakdi, 2010).

Basically, Cloud computing success arrives from its capacity to support providers requirements, services-oriented infra-structures and economy requirements, emergent (virtual) enterprise requirements, and user requirements (Xu, 2012). However, interoperability, security and QoS details involving all “stakeholders”, including distinct cloud models, bring this “success” hard to get and questionable (Mulholland, Daniels, & Hall, 2008).

Cloud Manufacturing represents a shift from production-oriented to service-oriented manufacturing, being services IT instances of (traditional) resources. Thus, the existence of efficient protocols and APIs (Application Program Interfaces) to manage cloud services (Services Oriented Architecture (SOA) Governance area), easily supports the required dynamic resources allocations and coordination of cloud Manufacturing (Bo-hu et al., 2010).

Cloud-based application architectures (Betts et al., 2010) present a “transparent” layer between presentation

layer (client interaction) and business and data layers (business rules and contents in cloud, mainly).

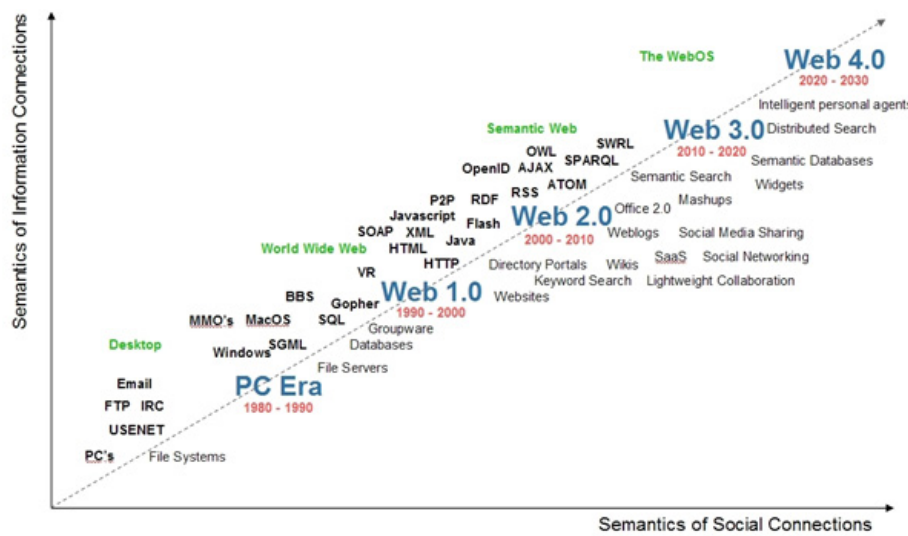


Figure 1. Web 4.0 brings intelligence^a

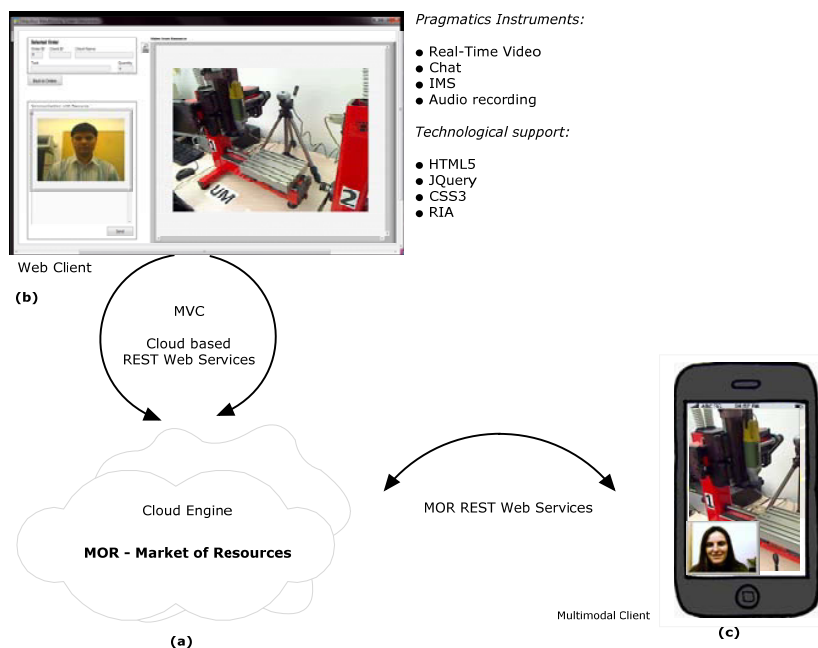


Figure 2 . UMS Supporting Architecture

^a Radar Networks & Nova Spivack, 2007

Application's Presentation Layers are now structured in a set of widgets (cloud-based full-fledged applications (W3C, 2011) or *cloudlets* as e.g. *Podio*^b specialized work apps or *Google Apps Marketplace*), each one, owning its graphical representation, support a service that can easily be “composed” (integrated) in a dashboard “*expected to improve decision making by amplifying cognition and capitalizing on human perceptual capabilities*” (Yigitbasioglu & Velcu, 2010).

Despite of this, the components are not effectively integrated, but merely functionally organized, indeed. They don't interact. Furthermore, besides the restricted interoperability, the lack of effective and really integrated communicational instruments, essential to enable the user participation (embedding his experience) on decision processes, represents another important weakness.

ICT will continue to behave as a lever but the way technology is used might be more important than the technology itself. Technology generates legacy.

3. Cloudlet Architecture Dashboard

Considering mentioned problems, we propose an integrated architecture which sustains the management and coordination of cloud-based services (resources) to grant technological integration requirements, as well as, communicational instruments as pragmatics tools to support human-to-human interaction, granting effective user participation. This base architecture follows *Model-View-Control* (MVC) pattern and the interface follows the *RIA Presentation Design Pattern* (Cunningham, 2003), having resources and their governance services (M) hosted in cloud (Figure 2 (c)), cloud-based Representational State Transfer (REST) services to support business rules and actions (C) and multimodal Rich Internet Application (RIA) Presentation Layer (V) to allow multimodal device interaction with (Figure 2 (c)). The global Market of Resources will be supported by cloud-based mechanisms (brokering) inherent to SOA Governance. The services, as instances of manufacturing resources (machines, persons, enterprises, etc.), are autonomously maintained following asynchronous subscribing pattern, classified using SLA (Services Layer Agreement) and geo-referenced with spatial data.

The services selection must be agile, sufficiently effective and dynamic to allow advanced search criteria (time, priorities, quality of service, etc.) and react to services asynchronous status notification (free, off, occupied, etc.).

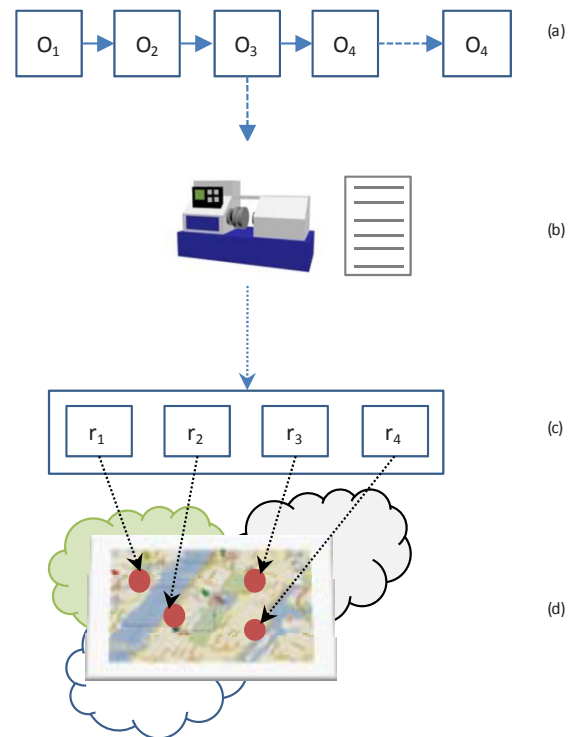


Figure 3- Cloud-based broker: (a) Process Plan (b) Stereotype (c) Candidate resources (d) Spatial Data in cloud

Resources' spatial data will provide/help on their localization on map using, for instance, distance, time, costs or facilities criteria. For each resource status and according to specific parameterization, alternative resources must be enabled by brokering service.

If it is not possible to get clear decisions about resources selection, or complementary resource information is needed, direct and synchronous communication must be allowed between stakeholders, so the user experience can be considered.

As a workflow overview, a Process Plan ((Figure 3, (a)) determines operations and resource specification (like a resource stereotype or meta-resource) (Figure 3, (b)) to handle them; broker finds candidates resources able to support it ((Figure 3, (c)), mapping them to resources on the ground (Figure 3, (d)). The mapping process is not necessarily automatic, but assisted with user participation, if needed, that is, using *Pragmatics* (Putnik et al., 2012).

Each resource represents a service (or many) that is hosted on cloud. It has an interface description language (IDL) that allows its discovery, an interoperability specification to follow and an (REST) API that allows its integration with (or, use by) other resources. So, each resource has its own “information system” to handle its work. “Residing” in cloud they are named *cloudlets*.

^b *Podio* is an emergent dashboard like online work platform



Figure 4- Cloudlet Architecture (a) Dashboards (b) Cloudlet (service) (c) Enhanced cloudlet (d) Cloudlet with pragmatics instruments

The application front-end has a RIA Presentation Layer behaving as a *dashboard* that, besides integrating common RIA web components, allows the management of each integrated cloudlet and global monitoring of associated resource (service).

RIA will be supported by emergent web 3.0 technologies (HTML5, JQuery, CSS3, etc.) and pragmatics instruments, communicational channels mainly, due to multimodality requirement, will be supported by open source communication technology as WebRTC and Web Media Capture.

So, each cloudlet is enhanced with layers representing enhanced services. Considering the spatial data representation on google maps, for instance, the map services (Figure 4 (a)): zoom, 3D, etc. (supported by google) will be enriched with advanced infowindows (Figure 4 (b)) where (existent) communicational channel links will be enable (email, SMS, chat, RT video, audio recording, etc.) and thus, in dashboard, a direct synchronous conversation with resource's owner will be possible if required (Figure 4 (c)).

4. Conclusions

Nowadays (web) business – eBusiness, uBusiness – requires workspaces that allow global management of different processes or work tasks. The time of multiple

“amazing integrated” applications (calendar, email, agenda, “internet”, etc.) were exceeded. Indeed, they were not really integrated, but organized, instead. Applications are now structured in several distinct and autonomous components, which requires almost no client resources, initially were Applets, now Services and Cloudlets in next. The idea is the same: execute the expected, independently of how it is done.

Cloud Computing brings out new opportunities and challenges and business and economic activities recognized that. Manufacturing reacted and Cloud Manufacturing evidences that. One can think that previous manufacturing resources' scalability, availability and reliability “problems” are overcome with cloud. Ubiquitous Manufacturing Systems try to show that. However to effectively achieve Cloud and Ubiquitous Manufacturing, the human capital must be present and that is only possible if user experience and user pragmatics are enabled in information systems.

This paper presents a cloudlet architecture for the RIA Presentation Layer of Cloud-based web information systems that behaves as a dashboard and really enables effectiveness with pragmatics instruments.

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